

Appl. No. : 10/067,634  
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## AMENDMENTS TO THE SPECIFICATION

Please replace the Abstract with the following replacement paragraph:

The present invention concerns a process for depositing rare earth oxide thin films, especially yttrium, lanthanum and gadolinium oxide thin films by an ALD process, according to which invention the source chemicals are cyclopentadienyl compounds of rare earth metals, especially those of yttrium, lanthanum and gadolinium. Suitable deposition temperatures for yttrium oxide are between 200 and 400°C **[a]** when the deposition pressure is between 1 and 50 mbar. Most suitable deposition temperatures for lanthanum oxide are between 160 and 165°C. when the deposition pressure is between 1 and 50 mbar.

Please replace paragraphs **[0013]** with the following replacement paragraph.

**[0013]** Despite the interesting properties of **[[La<sub>2</sub>O<sub>3</sub>]]** La<sub>2</sub>O<sub>3</sub>, possible applications of the La<sub>2</sub>O<sub>3</sub> thin films have been studied rather little for the time being. La<sub>2</sub>O<sub>3</sub> thin films have been used as optical and protective coatings. La<sub>2</sub>O<sub>3</sub> coatings have been used also in gas sensor and catalytic applications. However, because of the high dielectric constant and compatibility with silicon, La<sub>2</sub>O<sub>3</sub> is a possible gate oxide material in the future. Promising results have been recently reported by replacing SiO<sub>2</sub> with La<sub>2</sub>O<sub>3</sub> as a gate oxide.

Please replace paragraphs **[0020]** with the following replacement paragraphs.

**[0020]** Mölsä et al. (Adv. Mater. Opt. Electron. 4 (1994) 389-400) have grown Y<sub>2</sub>O<sub>3</sub> thin films in a flow-type **[[ALD]]** ALD reactor using Y(thd)<sub>3</sub> and oxygen or ozone as the source materials. The aim of the study was to produce a Y<sub>2</sub>O<sub>3</sub> buffer layer for high temperature superconductor films. The effect of the substrate material, pressure and pulsing time on the properties of the thin film was examined. The tested growth temperature range was from 425 to 600°C., which is too high for many applications. The growth rate was determined to be about 0.8 Å/cycle, but the growth rate was observed to increase with the increasing temperature. This indicates the lack of so called ALD window, which was the basic starting point for further studies of Putkonen et al. (Chem. Vap. Deposition 7 (2001) 44-50).

Please replace paragraphs **[0021]** with the following replacement paragraph.

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[0021] Putkonen et al. studied the ALD deposition of the  $\text{Y}_2\text{O}_3$  thin films in the temperature range of 200-425° C. by using  $\text{Y}(\text{thd})_3$ ,  $\text{Y}(\text{thd})_3(\text{bipyridyl})$ - or  $\text{Y}(\text{thd})_3(1,10\text{-fenantroline})$  compounds as the metal source and ozone as the oxygen source. A constant growth rate of 0.22-0.23 Å/cycle was observed in the temperature range of 250-350° C. for all source materials. The **[[ALP]]** ALD window representing the observed controlled growth is shown in **FIG. 2**. This temperature range is considerably lower than temperatures used previously in CVD depositions of the  $\text{Y}_2\text{O}_3$  thin films. However, the growth rate remained unpractically low. Also the hydrogen and carbon impurity levels were rather high. **FIG. 2** depicts carbon and hydrogen content as a function of the deposition temperature.

Please replace paragraphs [0023] with the following replacement paragraph.

[0023] Despite the application possibilities of  $\text{La}_2\text{O}_3$ , only few articles have been published in literature on the deposition of the  $\text{La}_2\text{O}_3$  thin films. Electron spray evaporation, different thermal vaporizing processes, pulsating laser deposition and atom spray deposition amongst physical methods have been used. Only pyrolysis, CVD, and ALD (Seim H. et al., Appl. Surf. Sci. 112 (1997) 243-250, Seim H. et al., J. Mater. Chem. 7 (1997) 449-454 and Nieminen N. et al. Appl. Surf. Sci., in press) ~~present~~ represent the chemical deposition methods.

Please replace paragraphs [0024] with the following replacement paragraph.

[0024] Nieminen et al. studied ALD depositions of  $\text{La}_2\text{O}_3$  using  $\text{La}(\text{thd})_3$  as a lanthanum source in order to find an ALD window. A temperature range from 180 to 425° C. was examined. Si(100) and soda lime glass were used as substrates. The growth rate of the films as a function of temperature is shown in **FIG. 4**. The pulsing time for  $\text{La}(\text{thd})_3$  was 0.8 s and for ozone 2 s. A constant growth rate of 0.36 Å/cycle was detected for the temperature range from 225 to 275°C. Therefore a self-controlling deposition process typical to ALD was observed at this temperature range. X-ray diffraction (XRD) measurements on films showed to be comparable with the data presented by Seim et al. Stoichiometry and carbon content of the films were determined by TOF-ERDA (Time-of-Flight Elastic Recoil Detection Analysis) and RBS (Rutherford Backscattering Spectrometry). The ~~earthe~~ carbon content depended on the deposition temperature (**FIG. 4**). However, in the range of the self controlled growth the

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elemental contents correspond to those of  $\text{La}_2\text{O}_2\text{CO}_3$ , indicating very poor quality of the resulted resultant film because of the carbonate incorporation. Bending vibrations were observed in the IR-measurements of films grown over 350°C because of the hydroxyl groups present in the film.

Please replace paragraphs [0026] with the following replacement paragraphs.

[0026] It is another object of the invention to provide a new process for depositing yttrium, gadolinium and lanthanum oxide thin films.

Please replace paragraphs [0041] with the following replacement paragraphs.

[0041] FIG. 9 shows the growth rate of the  $\text{Y}_2\text{O}_3$  thin films at deposition temperatures of 175-400°C.  $[[\text{CP}_3\text{Y}]]$   $\text{Cp}_3\text{Y}$  and water were the source materials. The vertical axis shows the growth rate [ $\text{\AA}/\text{cycle}$ ], and the horizontal axis shows the deposition temperature [ $^{\circ}\text{C}$ ].

Please replace paragraphs [0053] with the following replacement paragraphs.

[0053] FIG. 21 shows  $2\mu\text{m} \times 2\mu\text{m}$  AFM pictures of  $\text{Y}_2\text{O}_3$  thin films deposited from  $[[\text{CP}_3\text{Y}]]$   $\text{Cp}_3\text{Y}$  and water on Si(100);

Please replace paragraphs [0060] with the following replacement paragraphs.

[0060] FIG. 22 shows an X-ray diffraction pattern of a 75-nm  $[[\text{Gd}_2\text{O}_3]]$   $\text{Gd}_2\text{O}_3$  thin film grown on GaAs substrate.

Please replace paragraphs [0069] with the following replacement paragraphs.

[0069] Generally a “thin film” refers to a thin coating on a surface prepared by any thin film deposition method up to a thickness of approximately 1  $\mu\text{m}$  onto a substrate.  $[[\text{Tin}]]$  Thin films are used in fields of technology for numerous different applications. General range of uses

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are, inter alia, components in microelectronics, corrosion protecting coatings, applications of optoelectronics, different sensors and magnetic applications.

Please replace paragraphs [0084] with the following replacement paragraphs.

[0084] The present invention generally utilizes various cyclopentadienyl and cyclooctadienyl compounds of rare earth elements. These source compounds can be selected from a group of consisting of the following compounds:

$(Cp)_xM$  (I);

$(Cp)_xL_yM$  (II);

$(Cp)_xW_nM$  (III);

$([CP]Cp)_xL_yW_nM$  (IV);

Please replace paragraphs [0088] with the following replacement paragraphs.

[0088] W is some other ligand with a valence of -1 than Cp and where n denotes the number of the ligands. W is preferably beta-diketonate or its corresponding sulfur or nitrogen compound, halide, amide, ~~alkokside~~ alkoxide, carboxylate or Schiff's base. It must be noted that cyclooctadiene is usually shortened as Cod, but here the presentation is simplified by the use of the single common abbreviation Cp for both cyclopentadienyl and cyclooctadienyl.

Please replace paragraphs [0103] with the following replacement paragraphs.

[0103] wherein G is —O—, —S—, or —NR<sup>1</sup>, where R<sup>1</sup> is hydrogen or substituted or unsubstituted, cyclic, linear or branched, alkyl, alkenyl, aryl, alkylaryl, arylalkyl, alkoxy, thio, cyano or silyl group. A cyclic or aromatic ring in R<sup>1</sup> may contain a ~~heteroatm~~ heteroatom. Hydrogen or R<sup>1</sup>-type substituent may also be attached to the carbon atoms in chemical equation V, or

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Please replace paragraphs [0112] with the following replacement paragraphs.

[0112] "Reactive oxygen source" as used herein refers to any oxygen-containing source material capable of forming rare earth oxide on a substrate when the said oxygen-containing source material vapor is contacted with the rare earth compound that has chemisorbed on a substrate. The reactive oxygen source may consist of atomic oxygen (i.e., oxygen plasma), molecular oxygen (i.e., O<sub>2</sub> and/or O<sub>3</sub>), oxygen radicals (such as OH) or oxygen bound to other atoms in a molecule (such as [[H<sub>2</sub>O]] H<sub>2</sub>O, H<sub>2</sub>O<sub>2</sub>, organic peroxides or peracids).

Please replace paragraphs [0157] with the following replacement paragraphs.

[0157] Y<sub>2</sub>O<sub>3</sub> films were grown according to examples 1, except ~~that ozone~~ that ozone and a ~~mature mixture~~ mature mixture of ozone and water were used instead of plain water as an oxygen source material.